

# **Malheur National Forest Invasive Plants Treatment Project**

## **Hydrologist's Report**

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for:

Malheur National Forest

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## Introduction

This report will analyze the effect of herbicide and manual treatment on 2,123 acres where invasive plants have been identified. The Affected environment section will briefly describe the landscape: geology, climate, soil and stream flow responses which are important parameters either in the groundwater transport model used to determine the fate of the chemical herbicides or assessing the relative risk to water quality of particular sites.

### *Overview of Issues Addressed*

Calculations of water and soil concentration of applied herbicides, under specific conditions of the infested areas are the primary measurement used for this analysis. These values will be compared to levels of concern (LOC) for aquatic organisms.

Sediment produced by manual treatment of invasive plants will also be discussed. The impact of this method in the context of the forest-wide activities, on-going and foreseeable, that are ground disturbing, will be basis of analysis.

### Issue Indicators

Results of modeling for water and soil concentration will be reported in parts per million (ppm). Sedimentation from manual methods will be analyzed by determining probable affected acres within the scope of major watershed area.

## Affected Environment

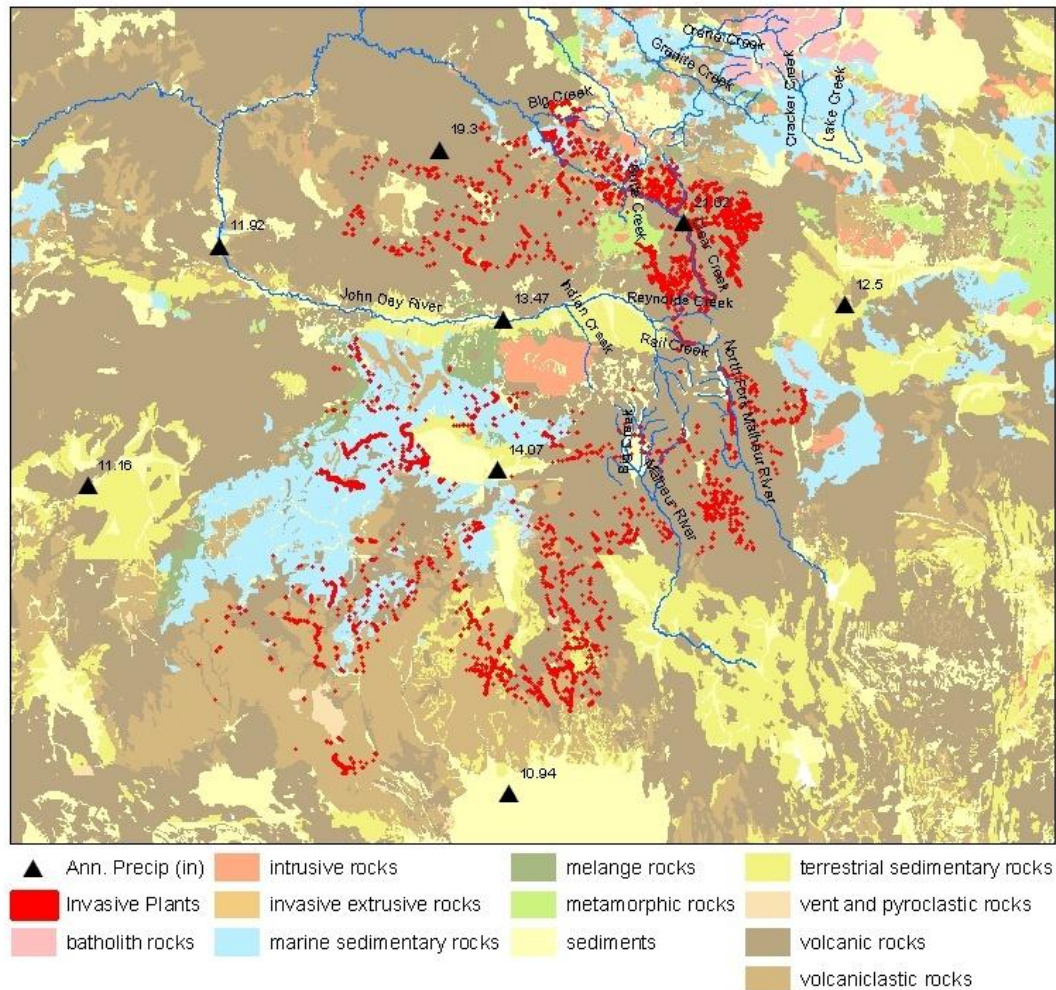
### *Existing Condition*

#### Geology

The geology of the Malheur National Forest is amongst the oldest and most complex in Oregon. Remnants of a shallow seafloor and sediments thereon were accreted onto the one-time edge of the North American tectonic plate (Brooks 1979). Under pressure and heat these layers were metamorphosed into argillites, quartzite, amphibolites that predominate in the center of the Forest, Aldrich Mountain and Bear Valley Basin. This process was concomitant with volcanism, and intrusion of oceanic crust, which are the frequent large bodies of serpentine common to the areas mentioned. A thick sequence of sediment, eroded from the one-time coast range, approximately where the Blue Mountains are today, deposited into the John Day geosyncline. These sediments are the mudstone, shale, graywacke and volcanic rocks that overlay the earlier seafloor sedimentary rocks, but now in turn, are often eroded away to expose the older rock.

Starting about 35 million years ago massive volcanism and attendant uplift resulted in widespread and thick sequence of basalt and andesite lava flows from vents and fissures, interlayered with pyroclastic tuffs, as well as conglomerates and breccia created during erosive periods between bouts of volcanism. Much of the Forest is covered by the Clarno, John Day, Strawberry and Columbia Group basalts and andesites (Brown and Thayer, 1966; Greene et al, 1972). These rocks frequently compose the upper ridges and mountain tops, except in the northeast quadrant where uplift and erosion has led to extensive exposure of old seafloor sediments or granitic batholith.

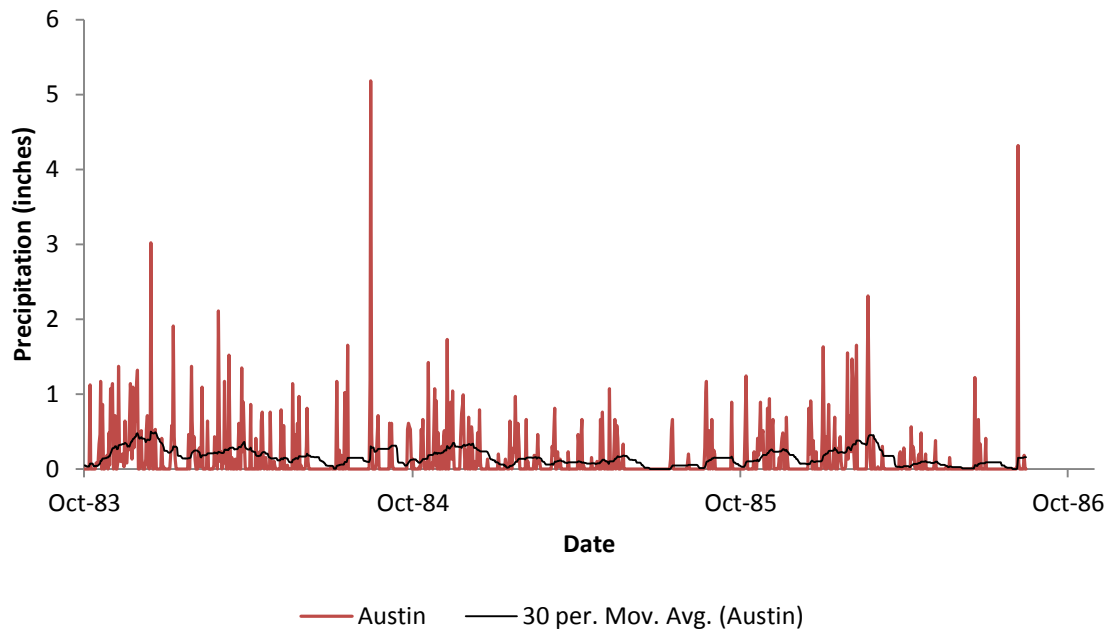
The larger valleys, the John Day, Bear Valley Basin, for example are filled with recent (Holocene) alluvium, but there are also extensive coarse sediment fans of the Pliocene and Pleistocene epoch on lower slopes and bottoms of the larger valleys.



**Figure 1 Geology and location of invasive plants**

## Climate

The climate of the Forest is cold winters and warm summers, total precipitation is modest. Annual averages from operating weather stations in and around the Forest range from 21 to 11 inches, at elevations between 3,000 and 4,600 feet (figure 1) (WRCC 2013). Precipitation is distributed across the year, most between the months of October and May as snow, with relatively dry summer months. But the occurrence of the largest events varies considerably, with occasional summer convective storms bringing high intensity rainfall. Figure 2 below shows the Austin weather station (elevation 4,200') for select years. The Austin station is near the headwaters of the Middle Fork John Day River, within the Forest boundary. A thirty day moving average was added in order to smooth the graph and clearly show seasonal pattern.



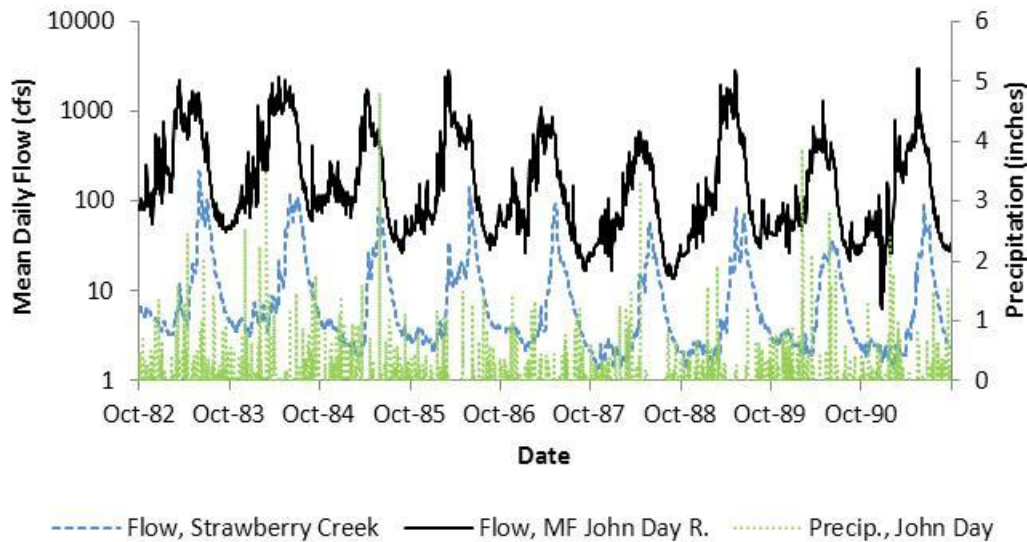
**Figure 2 Precipitation pattern at Austin weather station**

### Stream Flow

There are few gauged streams in the Forest, and fewer yet with overlapping records. Two gauges are used here for comparison. The Middle Fork John Day at Ritter (USGS station # 14044000) (USGS 2013) has a drainage area of 515 square miles. The gauge is at an elevation of 2,545 feet. It drains the northeastern portion of the Forest. Strawberry Creek (USGS station #14037500) drains 7 square miles of the north flank of Strawberry Mountain. The gauge is at 4,900 feet elevation.

Figure 3 shows mean daily flow for period of record overlap. The patterns of flow are nearly identical, though Strawberry Creek lags by a month or more in peak flow. Both are snowmelt dominated in terms of peak flow and total yield, between the months of March and May for the Middle Fork, and typically June and even early July for Strawberry Creek.

The geology of Strawberry Creek watershed is entirely within the Strawberry Formation, basalt and andesite lava rock. The Middle Fork has a majority of its drainage in volcanic rock of the Strawberry, Columbia River Group or Clarno, but also significant amounts of area in granitics and serpentinites and meta-volcanics of the Canyon Mountain Complex. The precipitation record from the John Day weather station is given as well to show the influence of events. Heavy rainfall in the summer or early fall can cause minor peaks in the hydrograph, but the occurrence of annual peak flow and most of flow yield is due to snowmelt runoff in late spring—early summer and is typically regardless of precipitation amount.



**Figure 3 Stream flow at selected gages and precipitation at John Day**

### Water Quality

The anti-degradation EPA policy 40 C.F. R. Section 131.12 states that existing water quality, even when it exceeds required levels for stated beneficial uses will be maintained. The MNF Land and Resource Management Plan stated direction for water quality is to meet state of Oregon standards (IV-2) and comply with state requirements in accordance with the Clean Water Act (IV-39); website: [http://www.fs.usda.gov/detail/malheur/landmanagement/?cid=fsbdev3\\_033814](http://www.fs.usda.gov/detail/malheur/landmanagement/?cid=fsbdev3_033814)

Use of water quality and other resource protection BMPs (USDA Forest Service, 2012) in National Forests is required by the National Forest Management Act (NFMA). Pertinent practices to this project assure proper mixing, application and clean-up as well as evaluation and monitoring of application that guard against use on unintended targets. Project design features, particularly parts F, G and H (see Chapter 2, table 9) incorporate BMPs on the handling of chemicals (Section 5, (8—13).

There are 6,220 mapped miles of stream channel on the Forest. About 2,788 miles or 45 percent of the total is mapped as perennial, meaning flow is typically sustained beyond the influence of wet season or snowmelt through most of the year.

Section 303(d) of the Clean Water Act (1972) requires that the state list water bodies, on biennial basis that do not meet minimum requirements for stated beneficial uses. The State of Oregon Department of Environmental Quality is the responsible agency for assessing and listing impaired streams. As of this writing the 2012 report was not complete. The 2010 list is referenced (<http://www.deq.state.or.us/wq/assessment/assessment.htm>). Category 5A streams are those listed and needing an EPA approved Total Maximum Daily Load (TMDL) of pollutant allowed to meet water quality standards. Category 4A streams are those that have approved TMDL, and have subsequently been de-listed from the 303(d).

Category 4A streams within the Forest boundary are the John Day River system, including the Middle Fork and South Fork and their tributaries with approved TMDL for temperature. Issues are water temperature for life stages of red band and cut throat trout. Category 5A streams are within the Silvies River system and include Hay, Myrtle and Skull Creeks for water temperature;

and within Silver Creek system: Nicoll, Claw, Sawmill, Salt Canyon and main-stem Silver for water temperature.

Other streams listed yet with insufficient information are the Middle Fork John Day and the following tributaries: Long Creek, Deadwood, and Vinegar for bio-criteria, Long and Summit Creeks for sediment. The Silvies River and following tributaries: Camp, Bear Canyon, Van Aspen Antelope for bio-criteria, and main stem Silvies for dissolved oxygen. Finally the upper John Day River is listed for bio-criteria, dissolved oxygen and sediment.

**Table 1 Beneficial uses of major streams on Malheur NF**

<b>Category 5A</b>	<b>Category 4A</b>	<b>Insufficient Information</b>		
		<i>Dissolved Oxygen</i>	<i>Bio-criteria</i>	<i>Sediment</i>
Silvies R. and Silver Crk.	M. and S. Fk. John Day R. and tributaries	Up. John Day R.; Silvies R.	M. Fk. John Day R. and tributaries (Long, Deadwood and Vinegar crks); Up. John Day R.; Silvies R. and tributaries	Up. John Day R., Long and Summit Cks. on M. Fk. John Day R.

### Occurrence of Invasive Plants

Most mapped invasive plants occur along, or near Forest roads. Since roads are preferentially routed up valley bottoms to access ridges, they are built alongside higher order (3<sup>rd</sup> and 4<sup>th</sup>) streams which constitute the majority of the Forest's perennial streams. Equipment, human and livestock travel along the roads is the main avenue for seed distribution, and the disturbed ground immediately adjacent to the road running surfaces are disposed to growing weedy types. Total invasive acreage mapped is 2,123. Mapped acreage within 33 meters of classified Forest roads is 1,312 or 61% of total and within 100 meters of a road are 1,725, or 81% of the total (see table 2).

There is a strong association between Forest roads and perennial stream channels. Forest system road mileage within 100 meters of mapped stream courses, is 2,138 or 34% of the total stream mileage. Perennial stream mileage within 100 meters of a road is 1,161, or 42% of that total. Because roads are prone to surface runoff from precipitation events, road drainage when in close proximity may discharge directly into streams. The close association of invasive plants to roads and roads to perennial streams are important considerations in analysis of herbicide transport beyond its point of application.

471 acres of mapped weeds are within 33 meters of streams. Eighty-one percent of this acreage is associated with roads within 300 feet, showing again the correlation of roads to weed occurrence.

**Table 2 Acreage of occurrence of invasive plants near roads and streams**

<b>Type of Occurrence</b>	<b>Acres of mapped invasive plants</b>	<b>Percentage of total mapped invasive plants</b>
Within 33 m of Forest roads	1,321	61
Within 100 m of Forest roads	1,725	81
Within 33 m of streams	471	22



## Municipal Watersheds and other Domestic Drinking Water Sources

The following table outlines those sources of public drinking water with all or partial watershed area on the Forest. With each source the amount of infested area that may be treated is also included.

**Table 3 Drinking water sources**

Site Name	Source	NFS acres in watershed	Comments
<b>Municipal : Streams with Surface Water Intake</b>			
Canyon City	Byram Gulch	610	Flows directly from Strawberry Mtn Wilderness
Prairie City	Dixie Creek	9300	0.44 acres of infestation, none within 100 feet of stream
Long Creek	Tributary of Long Creek	224	0.1 acres of infestation
<b>Springs with Formal Agreement</b>			
Canyon Creek Meadow	EF Canyon Creek	4200	0.2 acres of infestation, none within 200 feet of stream
Dixie Campground	Trib. Of Bridge Creek	470	0.23 acres of infestation, but none upstream of campground
Idewild Campground	Devine Canyon	350	About 0.1 acre of infestation within campground, and 1.0 acre along roads on watershed slopes
Magone Lake Campground	Lake Creek	150	0.36 acre of infestation along shore of the lake downstream of campground and none within 100 feet of stream.
Parish Cabin Campground	Bear Creek	14000	1.5 acre of infestation along roads within watershed. 0.1 acre within 100 feet of stream about 5 miles above campground
Strawberry Campground	Strawberry Creek	2300	No infestation in watershed.
Trout Farm Campground	Trib. of John Day R.	300	No infestation within watershed
<b>Wells with Formal Agreement</b>			
Big Creek Campground	Big Creek	16400	7.2 acres of infestation along roads within watershed, about 2 acres within 100 feet of stream
John Day	John Day River	100000	Forest or District
Mount Vernon	John Day River	200000	
Seneca	Silvies River	123700	
Yellowjacket Campground	Yellowjacket Creek	3700	About 7.7 acres of infestation within watershed, and about 4.7 acres within campground area. About 2.5 acres within 100 feet of stream or reservoir.
Austin House Restaurant	Bridge Creek	11000	About 1.2.5 acres of infestation, most along Hi-way 26

## Discussion

During the droughty summers typical for the project area, the soil water content is brought down to very low levels through evaporation and osmotic pressure. Whatever water had percolated into the soil column beyond the rooting depth will tend to stay in place in the drier months because of lack of hydraulic head.

In the fall, initial dry soil conditions create a sporadic and weak stream flow response. Most infiltrating rain water is simply absorbed by the soil, filling empty pores, bounding to soil particles. Air trapped within the pores, however, also exerts resistance to infiltrating water

(Wangemann et al, 2001). Even with high volume rainfall, stream response may be slight until soil pores fill with water beyond field capacity and hydraulic head builds. As soil moisture increases into winter stream flow increases, sustaining broader peaks, even with smaller precipitation events. By late spring and through summer higher temperature, low relative humidity and typical absence of rain causes a sharp, steady decline in flow (figure 3).

Herbicides that are highly water soluble or strongly adsorbed to soil particles have the potential to move off site following application. Once into solution herbicides may transport through the soil as groundwater flow, potentially reaching natural surface water bodies. However, as groundwater is dispersed through a soil there is also increasing chance that chemicals will adsorb to the soil. The depth of a wetting front for precipitation events immediately following herbicide application marks the probable depth of penetration of chemicals and an accumulation zone from additional applications of herbicides.

Direct foliar application lowers offsite effects for leaching. If rainfall were to occur during application or within the first day after, the risk for leaching exists for all the herbicides. Project design features (PDF) H11 gives parameters on allowable weather conditions for spraying.

Runoff risk is particularly high for saturated soils during snowmelt, because of low infiltration capacity. Spraying in spring when soil moisture is high and groundwater flow active may pose greater risk to transport of chemicals than in early fall when soil moisture content is very low, even under the same conditions of precipitation. Chemicals move into the soil with infiltrating precipitation, but depth of initial movement is important. A contaminated wetting front that stops in the top few inches of the soil, in the zone of microbial activity, would degrade faster. Herbicides infiltrating into soil with high water content and active gravity flow may quickly percolate beyond the range of most soil biota that would reduce the chemical. Herbicide half-life (the time it takes half the chemical to degrade), increases sharply when in groundwater. PDFs H5 and H6 limit herbicide spraying in conditions of high water table or saturated soils

The greatest risk to water contamination from herbicide spraying is the possibility of transport of residue on roads that may have direct connection to a stream channel. In these circumstances engineered drainage features may effectively circumvent buffers.

### *Desired Condition*

The anti-degradation EPA policy 40 C.F.R. Section 131.12 states that existing water quality, even when it exceeds required levels for stated beneficial uses will be maintained. The Forest Land and Resource Management Plan stated direction for water quality to meet state of Oregon standards (IV-2) and comply with state requirements in accordance with the Clean Water Act (IV-39); website: [http://www.fs.usda.gov/detail/malheur/landmanagement/?cid=fsbdev3\\_033814](http://www.fs.usda.gov/detail/malheur/landmanagement/?cid=fsbdev3_033814)

## Environmental Consequences

### *Methodology*

Analysis for herbicide effects used published assessments (SERA, 2001, 2004a-d, 2005, 2007, and 2011a-d), which provided parameters of degradation in various mediums, adsorption in soil, solubility in water, and toxicity to aquatic organisms. These parameters were used to assess potential risk of chemical transport in groundwater, effect to organisms in natural water bodies, and effectiveness of stream buffers. Assumptions are that herbicide application rates would be no more than the maximum rate shown in table 5 of the proposed action. Analysis for manual

methods assumes that soil cover guidelines provided in project design features for the soils section of the EA are followed.

### **Spatial and Temporal Context for Effects Analysis**

Project duration is 5-15 years. Repeated treatments, manual, mechanical or chemical may be necessary in sequential years or the same year on the same ground. There is the potential, under the proposed action that a given site will be impacted for up to 15 years and whatever recovery time necessary after that to mitigate the effects of soil disturbance or persistence of various chemical herbicides. The proposed action also provides for additional treatment of newly invaded sites during the life of the project.

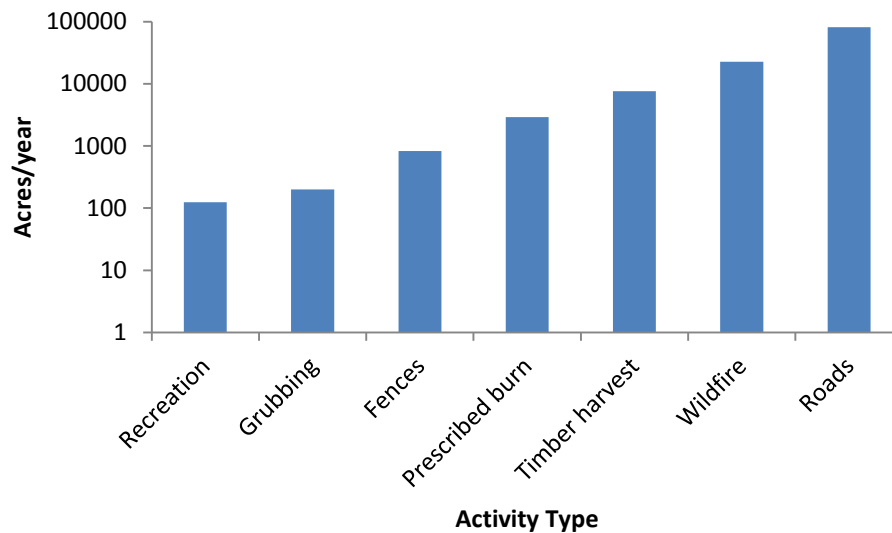
### **Early Detection Rapid Response (EDRR)**

New or previously undiscovered infestations of invasive plants would be treated using the range of methods described in chapters 1 and 2 of the EA, and in accordance with the project design features.

Early Detection Rapid Response (EDRR) is an essential component of the proposed action because the precise location of target plants is subject to change, and new infestations may grow substantially in area during the time taken to prepare new NEPA documents. The highest risk is for spread along infested roadways that provide open sites for weeds and high propagule pressure from passing traffic. The current use of project design measures and direct spray applications would limit offsite effect from runoff, erosion transport and leaching as discussed above.

### **Past, Present, and Foreseeable Activities Relevant to Cumulative Effects Analysis**

Current herbicide use on the Forest is limited to state highways. Figure 4 shows average activity level by category over the last 20 years. It includes manual removal of invasive plants (grubbing) that is treatment for invasive plants under categorical exclusion. . The list of foreseeable future activities for the years 2013-2015 include: prescribed burning, plantation thinning, replacing road culverts, road decommissioning, snow park relocation, aspen release, juniper thinning, toilet replacement, commercial timber harvest, parking lot paving, gate replacement, demolition of a structure by explosion, fencing and other sundry and related activities. Current level of manual removal of invasive plants has been about 200 acres a year or 0.17% of the total average ground disturbance.



**Figure 4 Average acreage of activity type per annum**

## *Alternative A – No Action*

### Direct and Indirect Effects

There are no direct effects of choosing the no action alternative. Invasive plant treatments would continue on state road right of ways and easements within the Forest boundary but outside jurisdictional control. Current infestations may spread. Ground disturbing activities are the principle means of the spread of invasive plants given the propagule pressure and type of expected disturbance associated with surrounding land uses and activities. See chapter 3.1 of the EA for more information about the potential for spread of invasive plants over time within the Forest,

Alternative A addresses some public concerns by eliminating all herbicide use on the Forest. There would continue to be low or no risks or impacts from herbicides on human health, non-target vegetation and pollinators, soils, water, aquatic organisms, or wildlife.

There are no direct or indirect effects to water quality by chemicals or sediment in alternative A. There would be no manual and mechanical treatment of invasive plants beyond that mitigation which is an on-going occurrence with some ground disturbing activities.

### Cumulative Effects

By selecting Alternative A there are no direct or indirect effects and therefore no cumulative effects to water quality. Effects of invasive plants on riparian areas would continue unabated and the spread of invasives over time could exacerbate these effects.

## *Alternative B – Proposed Action*

The proposed action would allow spraying of herbicides on up to 2123 acres per year over the life of the project. In addition, the project includes biological, manual, mechanical, and cultural treatments, along with post-treatment restoration.

## Design Features and Mitigation Measures

The following PDFs will help to mitigate the effects of transport of chemicals through ground and surface water flow, and to the disturbance of riparian vegetation by spray operations. Road ditches, because of the possibility of direct hydrologic connection to streams through relief drains or crossings are especially addressed. To the extent a road ditch may resemble or function as a protect feature, such as a running stream, spring, wetland or area of seasonally high water table, the following design features apply, along with buffers appropriate to the feature type.

- In no case will imazapyr use exceed 0.70 lbs. a.i./ac. Broadcast application of clopyralid, glyphosate, picloram, sethoxydim, or sulfometuron methyl will not exceed typical rates across any acre. Spot spray of triclopyr would not exceed typical rates across any acre.
- H1. Follow herbicide use buffers shown below. Tank mixtures would apply the largest buffer as indicated for any of the herbicides in the mixture.
- H2. In riparian and aquatic settings, vehicles (including all-terrain vehicles) used to access invasive plant sites, apply foam, or for broadcast spraying will not travel off roadways, trails and parking areas if damage to riparian vegetation, soil and water quality, and aquatic habitat is likely.
- H3. Avoid using picloram and/or metsulfuron methyl on bare or compact soils, and inherently poor productivity soils that are highly disturbed. Poor soils include shallow soils less than 20 inch depth that lack topsoil and serpentine soils.
- H4. Do not use more than one application of imazapyr, metsulfuron methyl, or picloram on a given area in any two calendar years, except to treat areas missed during the initial application. Aminopyralid would not be broadcast in any are more than once per year.
- H5. Limit herbicide offsite transport on sites with high runoff potential including sites with: shallow seasonal water tables, saturated soils (wet muck and peat soils), steep erosive slopes with shallow soils and rock outcrop, or bare compacted and disturbed soils. Limit runoff by applying herbicide during the dry season with the lowest soil moisture conditions, where > 50% groundcover exists on shallow slope sites, and > 70% on steep slope sites, and/or at reduced rates.
- H6. For soils with seasonally high water tables, do not use picloram or triclopyr BEE and limit glyphosate use to aquatic label only.
- H7. Lakes and Ponds – No more than half the perimeter or 50 percent of the vegetative cover within established buffers or 10 contiguous acres around a lake or pond would be treated with herbicides in any 30-day period. This limits area treated within riparian areas to keep refugia habitat for reptiles and amphibians.
- H8. Wetlands – Wetlands would be treated when soils are driest. If herbicide treatment is necessary when soils are wet, use aquatic labeled herbicides. Favor hand/selective treatment methods where effective and practical. No more than 10 contiguous acres or fifty percent individual wetland areas would be treated in any 30-day period.
- H9. Herbicide use would not occur within 100 feet of wells or 200 feet of spring developments. For stock tanks located outside of riparian areas, use wicking, wiping or spot treatments within 100 feet of the watering source.

- H10. Use of triclopyr BEE is only allowed in dry upland areas that are not hydrologically connected to water bodies.
- H11. Do not spray when local weather forecast calls for a  $\geq 50\%$  chance of rain.

## Direct and Indirect Effects

### *Non-Herbicide Treatments*

Non-herbicide treatments include manual, mechanical, cultural and biological. Manual treatment has the highest likelihood of impact to water resources. Manual methods are hand-pulling or using hand tools. Ground disturbance would occur from drawing up a plant by its roots, or digging sufficiently to leverage roots out. Other treatments, cutting, clipping, mowing and mulching do not incur any disturbance of the ground. There is a short term risk of erosion from disturbed ground, particularly if in a high infested area a contiguous patch of ground is disturbed sufficient to initiate surface erosion, such as a road cut bank or fill slope. Post-treatment restoration (passive and active planting, seeding and mulching) would be part of all treatment prescriptions and would help treatment sites recover from ground disturbance.

The Water Erosion Prediction Program (WEPP) (Elliot 2004) was used to assess, quantitatively the impact of manual removal of invasive plants on sediment delivery. WEPP has a disturbed forest slope, and a forest road application, so that sediment produced from manual treatment and a typical forest road may be compared for amount of sediment produced on a unit area basis of an acre.

The WEPP model was used to estimate the amount of sediment that might be produced from manual treatment near streams where about 40 percent of the natural cover is retained. Assuming that the area is otherwise not compacted or rutted, about 2 pounds of sediment per acre per year was estimated to be produced. If the maximum acreage within a 6<sup>th</sup> field watershed within 100 feet of a stream were manually treated (50 acres) about 100 pounds of sediment (0.02 tons) would be produced. This amount would not be detectable or measurable, and would not have significant effects on water resources.

### *Herbicide Treatment*

Table 4 gives measured properties of proposed herbicides for soil adsorption, water solubility, toxicity to aquatic organisms, and degradation rates in various environments. Information was obtained from the Syracuse Environmental Risk Assessment publications (SERA, 2001, 2004a-d, 2005, 2007, and 2011a-d), contracted specifically for the USDA Forest Service.

3).

**Table 4 Herbicide buffer to stream channels and wetlands. All values in feet**

Herbicide	Perennial streams, wetlands, lakes and ponds and roadside ditches with surface water		Intermittent, ephemeral streams (dry at time of treatment)	
	Broadcast	Spot/Hand/Select	Broadcast	Spot/Hand/Select
Aquatic Glyphosate	60	Water's edge	Bankfull	No buffer
Aquatic Imazapyr	60	Water's edge	Bankfull	No buffer
Aquatic Triclopyr-TEA	Not Allowed	15	Not Allowed	Bankfull
Aminopyralid	Water's edge	Water's edge	No Buffer	No Buffer

Herbicide	Perennial streams, wetlands, lakes and ponds and roadside ditches with surface water		Intermittent, ephemeral streams (dry at time of treatment)	
	Broadcast	Spot/Hand/Select	Broadcast	Spot/Hand/Select
Clopyralid	100	15	60	Bankfull
Imazapic	100	15	60	Bankfull
Metsulfuron Methyl	100	15	60	Bankfull
Imazapyr	100	50	60	15
Sulfometuron Methyl	100	50	60	15
Chlorsulfuron	100	50	60	15
Picloram	100	50	100	50
Sethoxydim	100	50	100	50
Glyphosate	100	50	100	50
Triclopyr-BEE	Not Allowed	Not Allowed	Not Allowed	150

The following table 5 gives physical and chemical characteristics of the 11 herbicides being proposed for use. These characteristics are important in the following discussion of alternatives and analysis based on ground water transport model.

**Table 5 Herbicide physical/chemical properties**

Herbicide	Toxicity to Aquatic Organisms	Adsorption	Water Solubility (ppm)	Degradation Half-Life (days)		
				Soil Microbes	Water and Sunlight	Ground-water
Aminopyralid	low	low	205,000	14-343	0.6	127-447
Clopyralid	low	low	1,000	12-70	8-40	261
Chlorsulfuron	low	low	27,900	120-180	No Info)	37-168
Glyphosate	moderate	strong	12,000	3-130	4-11	50-70
Imazapic	No info	moderate	>2670	25-142	1-2	30
Imazapyr	low	low	11-13,500	210-2154*--in anaerobic conditions **	500 stable in anaerobic conditions	N/A
Methsulfuron (sp?)methyl	low	low	≈3,000-10,000 pH neutral	30-126	7-8	35 +
Picloram	low	low	200-400,000	18-300 in aerobic conditions; stable in anaerobic	2.6	14 aerobic; stable in anaerobic conditions
Sethoxydim	low	low	4700 @pH7	1-60 the high end of range is anaerobic	5-43	155+ @ pH7

Herbicide	Toxicity to Aquatic Organisms	Adsorption	Water Solubility (ppm)	Degradation Half-Life (days)		
				Soil Microbes conditions	Water and Sunlight	Ground-water
Sulfometuron methly	low	low	300 @ pH7	10-100	20-60	44-113
Triclopyr TEA	Inhibits fungal and bacterial growth	low	8,100	14-46	2-6 hours	6 hours
Triclopyr (BEE)	high	strong	2-23	0.2-40	0.5-8.7 Depending on pH	≈6

\*--Values in parts per million (ppm)

\*\*--Imazapyr half-life values influenced by strictly anaerobic conditions which are rare among treated sites on the forest; most likely associated with wetlands and wet meadows.

Herbicides will be sprayed or wicked on leaves and stems of target plants or cut stumps. Herbicide that falls onto the soil could travel offsite by surface runoff or groundwater flow.

There is elevated risk for surface runoff when soils are bared on steep or compacted ground. Most Forest soils have very low runoff potential if undisturbed and left with cover of litter or basal vegetation. Most Forest soils associated with weed sites are well to somewhat excessively well-drained. Rainfall intensity only rarely exceeds infiltration capacity of intact soils with cover.

Once in soil, herbicide not directly absorbed into plant roots is typically metabolized by microbes (Bollag and Liu 1990) with the exception of triclopyr, which is only degraded by hydrolysis. Hydrolysis is the process by which the water molecule breaks down a compound into at least two separate constituents. Half-life of herbicides in soil is affected by its rate of adsorption to soil particles or organic matter incorporated into the soil. The stronger the adsorption the more likely chemicals will be retained in top soil layers for microbial degradation. Organic matter in particular has an affinity for adsorption.

Degradation proceeds rapidly in presence of sunlight, or by soil microbes when soil moisture is ample. Soil moisture of less than 10% becomes a limiting factor in microbial activity (Davidson, 1998). Outside these environments—on the soil surface or within the top few inches of the soil where microbial activity is high—the half-life of herbicides is measured in months. All but one of the herbicides is relatively highly soluble and therefore will readily transport deep into a soil column with percolating water. The notable exception is triclopyr BEE which however disassociates through hydrolysis very quickly to triclopyr TEA, which has moderately high solubility.

### Surface Runoff

Resistance to surface flow on most natural surfaces is amply provided by vegetation and litter cover. Winnowing of sediment laden sheet flow can be as much as 90% effective by vegetative buffer of 30 meters in width, even on steep slopes (Castelle et al. 1994, Castelle and Johnson 2000, Fishcher and Fischinich 2004). It is unlikely that whole surfaces of treated areas would be made barren by herbicide treatment, if for no other reason that poisoned weeds would provide a dead organic cover on the soil. By the same token manual grubbing and hand pulling of weeds would leave the uprooted vegetation on the ground. PDF H3 avoids spray treatment on extensive bare areas or obviously poor surface conditions.



Treatment on roads does pose a greater risk to eventual surface water contamination because surface runoff from bare and or compacted surfaces within the road prism shed precipitation water more readily and frequently than natural slopes. In a study at Lake Tahoe, Grismer and Hogan (2005) showed runoff from bare road cut slopes have 10 to 50 times the runoff of similar intact native soils. Further and possibly more significant, road prism runoff from running surfaces and cut banks is often facilitated with engineered ditches and relief pipes. To the extent that drainage may lead onto natural slopes, road surface runoff may be buffered. However, road segments that cross streams or penetrate into stream buffers provide routes for contaminants to reach streams, whether from rutted running surface, roadside ditches or runoff projected onto natural slopes an inadequate distance from the channel for proper buffering.

Results from modeling are shown in table 6, and include a treatment along roads. These results agree well with monitoring results from applications on roads in Oregon's Willamette Valley by the Oregon Department of Transportation (Berg, 2004).

### **Soil Water (Interstitial) Transport**

Ten of the 11 proposed herbicides are highly soluble in water with solubility greater than 300 mg/l (Bautista and Bulkin 2008, *Forest Service Unpublished Internal Report*). Once into solution herbicides may transport through the soil as groundwater flow, potentially reaching natural surface water bodies. However, as groundwater is dispersed through a soil there is also increasing chance that chemicals will adsorb to the soil. The depth of a wetting front for precipitation events following herbicide application marks the probable depth of penetration of chemicals and an accumulation zone from additional applications of herbicides.

Direct foliar application lowers offsite effects for leaching. If rainfall were to occur during application or within the first day after, the risk for leaching exists for all the herbicides. PDF H11 lowers leaching risk by avoiding treatment within 24 hours of forecasted rainfall.

Runoff risk is particularly high for saturated soils during snowmelt, because of low infiltration capacity. Herbicide application of highly soluble chemicals is avoided during snowmelt when soils are likely to be saturated (PDF H5, H6).

Spraying in spring when soil moisture is high and groundwater flow active may pose greater risk to transport of chemicals than in early fall when soil moisture content is very low, even under the same conditions of precipitation. Chemicals move into the soil with infiltrating precipitation, but depth of initial movement is important. A contaminated wetting front that stops in the top few inches of the soil, in the zone of microbial activity, would degrade faster. Herbicides infiltrating into soil with high water content and active gravity flow may quickly percolate beyond the range of most soil biota that would reduce the chemical. Herbicide half-life (the time it takes half the chemical to degrade), increases sharply when in groundwater. PDF H10 safeguards against spraying under conditions of active infiltration or obvious saturated conditions, when herbicides most easily are transported deep into the soil column.

The Groundwater Loading Effect of Agricultural Management Systems (GLEAMS) model (Website: [http://www.tifton.uga.edu/sewrl/Gleams/gleams\\_y2k\\_update.htm](http://www.tifton.uga.edu/sewrl/Gleams/gleams_y2k_update.htm)), is used to examine the fate of herbicides in the rooting zone of the soil. It may be modified for site specific parameters of climate, soils, topography, vegetation cover and size and flow rate of natural water bodies and application rate of herbicides. The application rates used were on the high end of the range of expected as stated in the proposed action (table 5). The start date of the model runs was June 15 of any given year. Applications are once a year on that date.

Results of GLEAMS runs are shown in table 6 on selected sites. Three of the 4 sites were adjacent to streams with flow rates varying by an order of magnitude. Two of the streams are mapped as bull trout spawning and rearing reaches.

The scenarios presented in these initial runs are modeled on real sites on the forest that are considered for treatment and have high resource value. Sites 1, 2 and 4 are centered on a native surface road. Site 3 does not have a road running through the treated area, but the area is adjacent to a stream. Sites 1 and 4 are buffered from the streams by natural forested slope in excess of the buffer guidelines given in table 4. The water concentration values reported in table 7 are assuming an average width of the untreated slope between the stream and treated area.

In Site 2 however the road crosses the stream and therefore there is the possibility of runoff from the road surface, and the treated area adjacent to the road surface, entering directly into the stream. However a road is treated the same as any other disturbed treatment area with buffered zones as prescribed in table 4. Designed features listed above in this report are also applied to roads the same as other treated areas of the forest. For example road cuts may intercept groundwater flow and are classified as seeps. Forest soils besides roads may also be areas of seasonably high water table and therefore are treated like any other area of the forest.

In all cases buffers are applied suitable to the type of chemical used and broadcast spraying method, and as per table 4. In all model runs the highest application rate was used initially to calculate concentrations in the soil in the buffer below the treated field (table 6). A second model run at each site, calculates water concentration, uses an application rate based on output from the first run. This simulates the effect to a stream with a buffer between it and the treatment field. In all cases and for each chemical model run the water concentration was calculated below 1 ppb, or essentially below detectable limits.

Table 6 below outlines the first choice herbicides for both broadcast and spot spraying applications, together with estimates of acreage of treated sites each would be used on.

**Table 6. Summary of herbicide use under alternative B**

<b>First Year/First Choice Activity</b>	<b>Acres Assuming 100 Percent Coverage with Invasive Plants</b>
<b>Potential Broadcast Herbicide</b>	
Aminopyralid	1,180
Chlorsulfuron	71
Metsulfuron methyl	30
<b>Total Potential Broadcast Application Method</b>	<b>1,281</b>
<b>Potential Spot/Selective Herbicide</b>	
Aminopyralid	168
Chlorsulfuron	519
Metsulfuron methyl	156
<b>Total Potential Spot/Selective</b>	<b>843</b>

The PDFs do not allow broadcasting at maximum rates for most of the herbicides, and only allow spot spray at typical rates for triclopyr. For the GLEAMS modeling the maximum rates from the project pdfs or rate restrictions in effect in the state of Oregon (table 7).

**Table 7 application rates of project herbicides**

Active Ingredient	Typical Application Rate (lb per ac)	Highest Application Rate (lb per ac)
Aminopyralid	0.078	0.11
Chlorsulfuron	0.056	Oregon label 0.13
Clopyralid	0.35	0.5
Glyphosate	2	(3.5 per application, 7 per year)
Imazapic	0.13	0.19
Imazapyr	0.45	0.7 (on this project as per pdfs)
Metsulfuron Methyl	0.03	0.075
Picloram	0.35	1.0
Sethoxydim	0.3	0.47
Sulfometuron Methyl	0.045	0.38
Triclopyr	1.0	6 (Oregon label)

Under the EDRR, the higher application rates may be used. Below, table 8 outlines results for model runs using maximum allowable application rates on a specific site in the Forest, Ennis Creek.

The Ennis Creek site is along road 4110. It has moderately deep, gravelly clay soils. The modeled run assumed 10 acres are treated to the edge of this 2 cfs stream. The infested area is approximately 3 acres, however the acreage was increased in order to model the maximum amount of herbicide that might reach the stream given the EDRR cap of 10 riparian treatment acres within a 6<sup>th</sup> field watershed.

The model run assumed that 100 percent of the 10 acres are treated using the maximum allowable herbicide use rate. This run does not consider broadcast rate restrictions associated with clopyralid, glyphosate, picloram, sethoxydim, or sulfometuron methyl or the spot treatment rate restriction for triclopyr. The model does not differentiate between application methods so the maximum rates were assumed.

**Table 8 EDRR--no buffer on Humarel site-10 acre treated, 10 acre watershed above**

Chemical	App'l Rate (lbs/acre a.i.)	Conc. At 12" (Mg/l)	Conc. At 36" (Mg/l)	Water Peak Conc.' (Mg/l)	Eff. App'l Rate offsite (lbs/acre a.i.)
Aminopyralid	0.11	0.0192	0.0	0.0000	0.0000
Chlorsulfuron	0.13	0.0432	0.0	0.0007	0.0059
Clopyralid	0.5	0.0983	0.0	0.0001	0.0004
Glyphosate	3.5	0.6283	0.0	0.0000	0.0006
Imazapic	0.19	0.0566	0.0	0.0014	0.0135
Imazapyr	0.70	0.1644	0.0	0.0019	0.0145
Methsulfuron Methyl	0.075	0.0240	0.0	0.0030	0.0030
Picloram	1.00	0.2911	0.0	0.0040	0.0392
Sethoxydim	0.47	0.0891	0.0	0.0009	0.0064

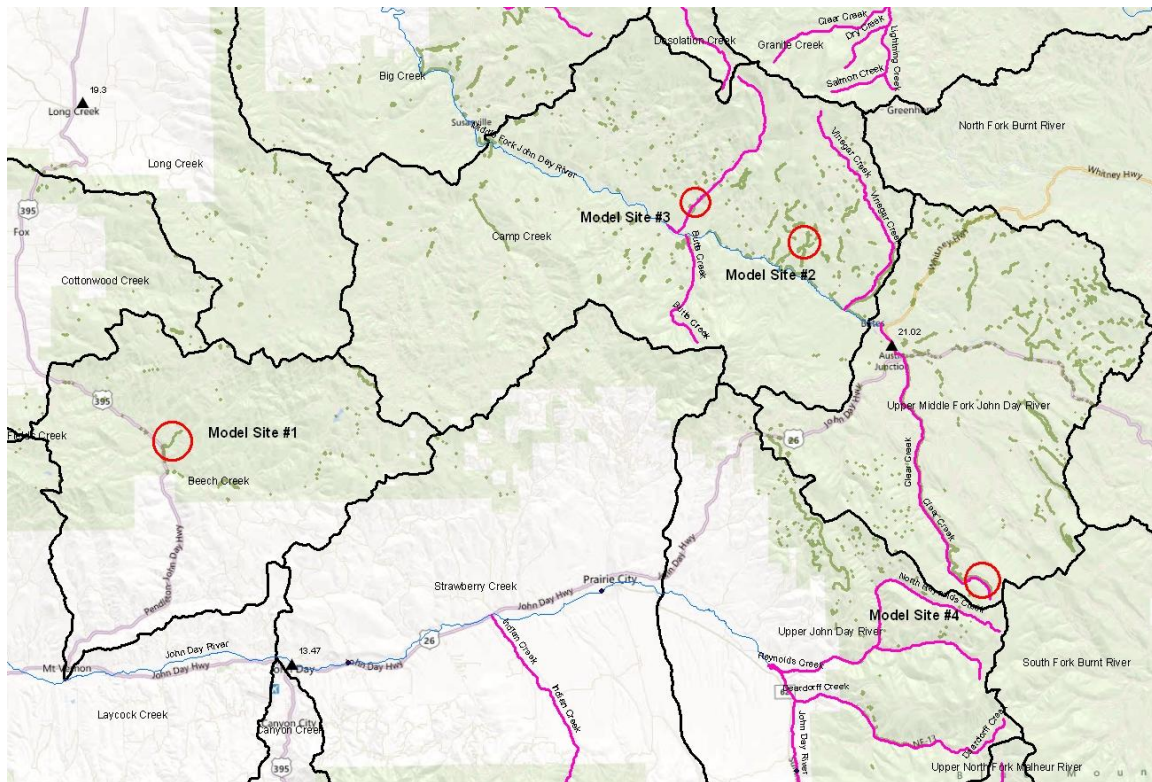
Chemical	App'l Rate (lbs/acre a.i.)	Conc. At 12" (Mg/l)	Conc. At 36" (Mg/l)	Water Peak Conc.' (Mg/l)	Eff. App'l Rate offsite (lbs/acre a.i.)
Sulfuron	0.38	0.0712	0.0	0.0002	0.0006
Triclopyr*	6.00	1.3363	0.0	0.0045	0.0293

\*--GLEAMS does not model for ester form triclopyr BEE, only for Triclopyr TEA.

In soil and water the conversion of triclopyr BEE and TEA to triclopyr acid is rapid. Both BEE and TEA hydrolyze quickly in natural water. Microbial degradation also degrades triclopyr in water. Once TEA and TBEE convert to triclopyr, there is little toxicological hazard to aquatic organisms and triclopyr does not bio-accumulate (Ganapathy, 1997).

All runs show in table 8 used Austin 3S weather station near Austin Oregon. A 20 year weather set (p=0.05 for all runs) was chosen. The GLEAMS model incorporates climate data from local stations, in this case the station at Austin was chosen as it was close to the main area of infested sites on the Forest: the upper Middle Fork John Day River. The Cligen program developed by the National Soil Erosion Research Lab uses real weather data to generate simulated yearly data (Website: <http://www.ars.usda.gov/Research/docs.htm?docid=18094> ), and is uploaded by the GLEAMS program.

One application of chemicals was assumed per year. For reported concentrations, 0.001 Mg/l is approximately 1 ppb. These runs are considered to be the worst case scenario for action taken under EDRR rules, with no buffer between treated field and Ennis Creek stream channel and maximum allowable acreage in a given 6<sup>th</sup> HUC watershed. The Humacel soils series site is site 1 in figure 5 below.



**Figure 5 Location in Middle Fork John Day R. of GLEAMS model sites**

**Purple shaded streams are bull trout spawning and rearing; green shading is invasive plants sites**

Under alternatives B and D, chlorsulfuron, picloram, sethoxydim and sulfometuron methyl would not be used within 50 feet of a stream and clopyralid, imazapic, metsulfuron methyl and triclopyr TEA would not be used within 15 feet of a stream. The GLEAMS model does not explicitly incorporate distance from a stream thus the effect of these herbicide use buffers are not included for the “worst case” EDRR scenario. Aminopyralid (alternative B only) and aquatic formulations of glyphosate and imazapyr (alternatives B and D) could be used to the water’s edge. The “Water Peak Conc” shows the amount of herbicide (in mg/l or ppm) that would reach the stream assuming no buffer.

**Table 9. Alternative B and D EDRR Run - Ennis Creek Site 1**

<b>Chemical</b>	<b>App'l Rate (lbs/acre a.i.)</b>	<b>Conc. At 12" (Mg/l)</b>	<b>Conc. At 36" (Mg/l)</b>	<b>Water Peak Conc. (Mg/l)</b>	<b>Eff. App'l Rate offsite (lbs/acre a.i.)</b>
Aminopyralid	0.11	0.0192	0.0	0.0000	0.0000
Chlorsulfuron	0.13	0.0432	0.0	0.0007	0.0059
Clopyralid	0.5	0.0983	0.0	0.0001	0.0004
Glyphosate	3.5	0.6283	0.0	0.0000	0.0006
Imazapic	0.19	0.0566	0.0	0.0014	0.0135
Imazapyr	0.70	0.1644	0.0	0.0019	0.0145
Metsulfuron Methyl	0.075	0.0240	0.0	0.0030	0.0030
Picloram	1.00	0.2911	0.0	0.0040	0.0392
Sethoxydim	0.47	0.0891	0.0	0.0009	0.0064
Sulfometuron Methyl	0.38	0.0712	0.0	0.0002	0.0006

Chemical	App'l Rate (lbs/acre a.i.)	Conc. At 12" (Mg/l)	Conc. At 36" (Mg/l)	Water Peak Conc. (Mg/l)	Eff. App'l Rate offsite (lbs/acre a.i.)
Triclopyr*	6.00	1.3363	0.0	0.0045	0.0293

### Results

1. Results for all herbicides are below the threshold of concern for fish, algae, and invertebrates.
2. Results for metsulfuron methyl are above the threshold of concern and chlorsulfuron and sulfometuron methyl are slightly above or at the threshold for concern for aquatic plants. Individual aquatic plants could be adversely affected but the extent would be limited to a small area and would not be large enough to affect habitat or the aquatic food chain. The herbicide rate restrictions, buffers and treatment caps would likely eliminate the potential for harm to the aquatic environment or beneficial uses of water.
3. The Effective Application Rate offsite (eff. App'l rate offsite) is the amount of herbicide that would reach a non-treated buffer area.

### Site 2 Camp Creek HUC, FiveBeaver Soils

Site 2 is along road 7106. The infested area is 350 to 700 feet above the stream. The stream is 2 cfs. Table 3 shows the results for all herbicides and alternatives, however aminopyralid would not be used in alternative D and picloram would not be used in alternative C. Soils are more shallow and the slope is steeper than in site 1. Results are below the threshold of concern for fish, algae, aquatic plants and invertebrates for all herbicides except for sulfometuron methyl, which is near the threshold of concern for aquatic plants. No adverse effects on the aquatic ecosystem or beneficial uses of water are indicated by the model results.

**Table 10** Site 2 Results, All Alternatives

Chemical	App'l Rate (lbs/acre a.i.)	Conc. At 12" (Mg/l)	Conc. At 36" (Mg/l)	Water Peak Conc. (Mg/l)	Eff. App'l Rate offsite (lbs/acre a.i.)
Aminopyralid	0.11	0.0334	0.0	0.0002	0.0029
Chlorsulfuron	0.13	0.0311	0.0	0.0001	0.0021
Clopyralid	0.5	0.1055	0.0	0.0002	0.0020
Glyphosate	3.5	0.6486	0.0	0.0001	0.0004
Imazapic	0.19	0.0582	0.0	0.0003	0.0118
Imazapyr	0.70	0.0227	0.0	0.0001	0.0038
Metsulfuron Methyl	0.075	0.0248	0.0	0.0001	0.0026
Picloram	1.00	0.3030	0.0	0.0012	0.0341
Sethoxydim	0.47	0.0919	0.0	0.0002	0.0057
Sulfometuron Methyl	0.38	0.0807	0.0	0.0003	0.0067
Triclopyr	6.00	1.3705	0.0	0.0009	0.0228

### Site 3 Granite Boulder Creek, Melloe Soils

This site is a small treatment area (350 feet by 500 feet) along Granite Boulder Creek. The stream is 10 cfs. Table 3 shows the results for all herbicides and alternatives, however aminopyralid would not be used in alternative D and picloram would not be used in alternative C. Given the deep loamy soils and the effect of the herbicide use buffers in all alternatives, little to no herbicide would reach the stream from this treatment. Results for all herbicides are below the threshold of concern for fish, algae, aquatic plants and invertebrates. No adverse effects on the aquatic ecosystem or beneficial uses of water are indicated by the model results.

**Table 11 Site 3 Results Granite Boulder Creek**

<b>Chemical</b>	<b>App'l Rate (lbs/acre a.i.)</b>	<b>Conc. At 12" (Mg/l)</b>	<b>Conc. At 36" (Mg/l)</b>	<b>Water Peak Conc. (Mg/l)</b>	<b>Eff. App'l Rate offsite (lbs/acre a.i.)</b>
Aminopyralid	0.11	0.0268	0.0115	0.0000	0.0007
Chlorsulfuron	0.13	0.0302	0.0101	0.0000	0.0005
Clopyralid	0.5	0.1000	0.0348	0.0000	0.0003
Glyphosate	3.5	0.6282	0.2094	0.0000	0.0001
Imazapic	0.19	0.0570	0.0190	0.0001	0.0043
Imazapyr	0.70	0.2086	0.0697	0.0002	0.0012
Metsulfuron Methyl	0.075	0.0219	0.0076	0.0000	0.0008
Picloram	1.00	0.2809	0.0992	0.0002	0.0106
Sethoxydim	0.47	0.0892	0.0297	0.0000	0.0011
Sulfometuron Methyl	0.38	0.0785	0.0262	0.0001	0.0015
Triclopyr	6.00	1.3358	0.4453	0.0001	0.0037

#### **Site 4 Clear Creek HUC, Wonder Soils**

This site is along road 2255. The infested area is about 1.5 acres (1,180 feet x 50 feet) lying 180 to 250 feet above the stream. The stream is 2 cfs. This area has high runoff potential. Table 5 shows the results for all herbicides and alternatives, however aminopyralid would not be used in alternative D and picloram would not be used in alternative C. Results for all herbicides are below the threshold of concern for fish, algae, aquatic plants and invertebrates. No adverse effects on the aquatic ecosystem or beneficial uses of water are indicated by the model results.

**Table 12 Site 4 Results Clear Creek/Wonder soil series**

<b>Chemical</b>	<b>App'l Rate (lbs/acre a.i.)</b>	<b>Conc. At 12" (Mg/l)</b>	<b>Conc. At 36" (Mg/l)</b>	<b>Water Peak Conc. (Mg/l)</b>	<b>Eff. App'l Rate offsite (lbs/acre a.i.)</b>
Aminopyralid	0.11	0.0216	0.0103	0.0003	0.0001
Chlorsulfuron	0.13	0.0310	0.0104	0.0001	0.0013
Clopyralid	0.5	0.1054	0.0356	0.0001	0.0010
Glyphosate	3.5	0.6484	0.2161	0.0000	0.0002
Imazapic	0.19	0.0577	0.0192	0.0003	0.0073
Imazapyr	0.70	0.2117	0.0706	0.0008	0.0192
Metsulfuron Methyl	0.075	0.0246	0.0082	0.0001	0.0022
Picloram	1.00	0.2895	0.0976	0.0001	0.0273



Chemical	App'l Rate (lbs/acre a.i.)	Conc. At 12" (Mg/l)	Conc. At 36" (Mg/l)	Water Peak Conc.' (Mg/l)	Eff. App'l Rate offsite (lbs/acre a.i.)
Sethoxydim	0.47	0.09818	0.0306	0.0002	0.0027
Sulfometuron methyl	0.38	0.0806	0.0269	0.0002	0.0035
Triclopyr	6.00	1.3707	0.4659	0.0010	0.0111

Beneficial uses of the major streams draining the forest include municipal and domestic use, irrigation, livestock and aquatic habitat (State of Oregon, Department of Environmental Quality website: <http://www.deq.state.or.us/wq/rules/div041tblsfigs.htm#t1> ) However, no chemical herbicides have had standards developed for concentrations in water for the state of Oregon (website: <http://www.deq.state.or.us/regulations/rules.htm> ). A summary of acute and chronic toxicity is provided in a Biological Assessment for the R6 2005 FEIS (USDA 2005). *United States Department of Agriculture, Forest Service. 2005. Fisheries Biological Assessment for United States Department of Agriculture Forest Service, Pacific Northwest Region, Invasive Plant Program, Environmental Impact Statement. United States Department of Agriculture Forest Service, Pacific Northwest Region, Portland, OR. 221pp.*

Table 9 lists these chronic and acute thresholds from the BA. Thresholds for Aminopyralid is not covered in the programmatic are taken from SERA risk assessment for Aminopyralid (SERA, 2007a). It can be seen with a comparison of tables 6 and 7 that water concentrations from the model runs are at least 3 orders of magnitude less than levels of concern for fish, amphibians and aquatic invertebrates.

**Table 13 Toxicity indices for fish**

Indices represent the most sensitive endpoint from the most sensitive species for which adequate data are available. Numbers in red indicate the toxicity index used in calculating the hazard quotient for exposures to listed fish. Generally, the lowest toxicity index available for the species most sensitive to effects was used. Measured chronic data (NOEC) was used when they were lower than 1/20 <sup>th</sup> of an acute LC50 because they account for at least some sublethal effects, and doses that are protective in chronic exposures are more certain to be protective in acute exposures.					
Herbicide	Duration	Endpoint*	Dose**	Species	Effect Noted at LOAEL***
Aminopyralid	Acute	NOEC	50mg/l	Rainbow Trout	None available
	Chronic	NOEC	1.35 mg/l	Rainbow Trout	None available
Chlorsulfuron	Acute	NOEC	2 mg/L (1/20 <sup>th</sup> of LC50)	Brown trout	LC50 at 40 mg/L
	Chronic	NOEC <sup>1</sup>	3.2 mg/L	Brown trout	rainbow trout length affected at 66mg/L
Clopyralid	Acute	NOEC	5 mg/L (1/20 <sup>th</sup> of LC50)	Rainbow trout	LC50 at 103 mg/L
	Chronic				none available
Glyphosate (no surfactant)	Acute	NOEC	0.5 mg/L (1/20 <sup>th</sup> /LC50)	Rainbow trout	LC50 at 10 mg/L
	Chronic	NOEC	2.57 mg/L <sup>2</sup>	Rainbow trout	Life-cycle study in minnows; LOAEL not



Indices represent the most sensitive endpoint from the most sensitive species for which adequate data are available. Numbers in red indicate the toxicity index used in calculating the hazard quotient for exposures to listed fish. Generally, the lowest toxicity index available for the species most sensitive to effects was used. Measured chronic data (NOEC) was used when they were lower than 1/20<sup>th</sup> of an acute LC50 because they account for at least some sublethal effects, and doses that are protective in chronic exposures are more certain to be protective in acute exposures.

Herbicide	Duration	Endpoint*	Dose**	Species	Effect Noted at LOAEL***
					given
Glyphosate with POEA surfactant	Acute	NOEC	0.065 mg/L (1/20 <sup>th</sup> of LC50)	Rainbow trout	LC50 at 1.3 mg/L for fingerlings (surfactant formulation)
	Chronic	NOEC	0.36 mg/L	salmonids	estimated from full life-cycle study of minnows (surfactant formulation)
Imazapic	Acute	NOEC	100 mg/L	all fish	at 100 mg/L, no statistically sig. mortality
	Chronic	NOEC	100 mg/L	fathead minnow	No treatment related effects to hatch or growth
Imazapyr	Acute	NOEC	5 mg/L (1/20 <sup>th</sup> LC50)	trout, catfish, bluegill	LC50 at 110-180 mg/L for North American species
	Chronic	NOEC	43.1 mg/L	Rainbow	"nearly significant" effects on early life stages at 92.4 mg/L
Metsulfuron methyl	Acute	NOEC	10 mg/L	Rainbow	lethargy, erratic swimming at 100 mg/L
	Chronic	NOEC	4.5 mg/L	Rainbow	standard length effects at 8 mg/L
Picloram	Acute	NOEC	0.04 mg/L (1/20 <sup>th</sup> LC50)	Cutthroat trout	LC50 at 0.80 mg/L
	Chronic	NOEC	0.55 mg/L	Rainbow trout	body weight and length of fry reduced at 0.88 mg/L
Sethoxydim	Acute	NOEC	0.06 mg/L (1/20 <sup>th</sup> LC50)	Rainbow trout	LC50 at 1.2 mg/L
	Chronic	NOEC			none available
Sulfometuron methyl	Acute	NOEC	7.3 mg/L	Fathead minnow	No signs of toxicity at highest doses tested
	Chronic	NOEC	1.17 mg/L	Fathead minnow	No effects on hatch, survival or growth at highest doses tested
Triclopyr acid	Acute	NOEC	0.26 mg/L (1/20 <sup>th</sup> LC50)	Chum salmon	LC50 at 5.3 mg/L <sup>3</sup>
	Chronic	NOEC	104 mg/L	Fathead minnow	Reduced survival of embryo/larval stages at 140 mg/L
Triclopyr BEE	Acute		0.012 mg/L	Bluegill sunfish	LC50 at 0.25 mg/L
	Chronic <sup>4</sup>	NOEC	104 mg/L	Fathead minnow	Reduced survival of embryo/larval stages at

Indices represent the most sensitive endpoint from the most sensitive species for which adequate data are available. Numbers in red indicate the toxicity index used in calculating the hazard quotient for exposures to listed fish. Generally, the lowest toxicity index available for the species most sensitive to effects was used. Measured chronic data (NOEC) was used when they were lower than 1/20<sup>th</sup> of an acute LC50 because they account for at least some sublethal effects, and doses that are protective in chronic exposures are more certain to be protective in acute exposures.

Herbicide	Duration	Endpoint*	Dose**	Species	Effect Noted at LOAEL***
					140 mg/L

\*--NOEC = No Observed Effect Concentration

\*\*--LC50, Lethal Concentration, 50% kill

\*\*\*--LOAEL—Lowest Observed Adverse Effect Level

Bakke (2001) in a review of monitoring results after herbicide spraying on Eldorado and Stanislaus National forests found that buffers of greater than 20 feet were completely effective in eliminating Glyphosate and Triclopyr in detectable levels (about 0.5 parts per billion) in adjacent streams. Slight but detectable levels (0.5-2.4) were found when buffer widths were 10-15 feet for Glyphosate on the Stanislaus National Forest.

Berg (2004) in a comprehensive review of Best Management Practices associated with herbicide spraying in region 5 and elsewhere in the United States found similar results. Detectable levels of herbicides such as Glyphosate, Triclopyr and Clopyralid were found in various locations (Washington, Oregon, New York and Florida) mainly as a result of drift from boom broadcast spray or aerial application. An Oregon Department of Transportation study sampled runoff from road shoulders after treatment of Glyphosate, with no buffers on a stream. Under simulated rainfall of high intensity they found 100's of ppb could be transported off site. In a similar test, under natural rainfall 0.1-1 ppb was detected leaving the road prism. The results of these studies show that the GLEAMS results for this project are reasonable, and that the greatest risk is from roads with direct hydrologic connection to stream channels.

## Drinking Water Sources

Sources for public drinking water located in watersheds wholly or partially on the forest was listed above in table 3. These sources will be protected from treatment by the same Project Design Features (PDF) that are in affect across the entire forest (see Chapter 2 of project EIS, project record file). The GLEAMS runs demonstrate that the PDFs, at the rates of chemical application proposed, will protect water quality of surface and ground sources (streams, springs and wells) and maintain levels of concentration of chemicals well below thresholds of concern for human consumption.

## Cumulative Effects

Depths of maximum concentration presented in GLEAMS results are between 8 and 12 inches. This residue buildup in the soil does not affect water concentrations however, as the chemicals are strongly attracted to soil particles and not readily transported by water. Time between applications and the half-life of the various herbicides will minimize residue accumulations. Please note the PDF that helps eliminate soil build up (see H4 previously listed in this report). Applying herbicides at typical and not maximum recommended rates will limit the amount of

excess residue present on site each year, while the presence of soil microbes and soil temperatures conducive to degrading the herbicides will limit the amount of accumulation.

A list of foreseeable forest wide projects are scheduled 2013-2015 that will be concurrent with the proposed action. These projects include: prescribed burning, plantation thinning, replacing road culverts, road decommissioning, snow park relocation, aspen release, juniper thinning, toilet replacement, commercial timber harvest, parking lot paving, gate replacement, and demolition of a structure by explosion, fencing and other sundry and related activities. There is no other use of herbicide, although most of the activities will involve a level of ground disturbance and many will probably risk increasing sediment delivery to streams.

Below is the graph (figure 6) that shows average activity levels by type per year on the Forest which was shown before in the section Past, Present and Foreseeable Projects. Included in this graph is maximum annual treatment for the proposed action (labeled PROJECT in the graph), that could contribute sediment from manual treatments. This acreage is 471, which is all the treatment acreage within 100 meters of a stream, acreage that is most likely to have a direct hydrologic connection through surface flow. Altogether this acreage would be about 0.4% of average ground disturbing activity on the forest and at that level does not constitute a significant factor and would not be a detectable addition. Considering the GLEAMS model runs (table 6) only treated ground within 100 meters of streams or with a direct hydrologic connection (as through a ditch running water) would be at risk of even detectable levels of chemicals at peak concentrations.

The most ground disturbing activity that might occur is manual treatment within 100 feet of stream. An analysis was done to compare the amount of sediment that might be produced assuming that the maximum acreage was manually treated (the treatment that might produce the most sediment) to the amount of sediment annually produced by Forest roads. The following parameters were used for inputs into WEPP for the forest road application: 0.5% grade, 14 feet wide, in-sloped but not ditched with medium traffic.

Idaho Creek-Summit Creek HUC6 was used because it currently has the largest concentration of mapped invasive plants at that watershed level within 100 feet of a mapped stream; a total of 51.29 acres. Also within the Idaho-Summit Creeks watershed is 10.9 miles of forest roads within 100 feet of a mapped stream, or approximately 18.5 acres of running surface which equals 37 tons of sediment per year versus 0.05 tons from manual treatment. The road surfaces are contributing sediment every year though rates will vary widely according to slope and drainage.

#### DES-OCHO\_CRG Cumulative Effects of All Action Alternatives

The 6th-field subwatershed scale was analyzed to establish the extent to which cumulative effects might occur. None of the alternatives have much potential to adversely affect water quality or contribute to adverse effects at the 6th field subwatershed scale. Most of the National Forest System lands analyzed in this FEIS are in headwater areas (upstream of other sources of herbicides). When project design features are implemented, the spatial extent of effects of herbicide use would be limited to the site of application, and governed by the extent of the target species to be treated. The scattered nature of treatments, treatment caps, and relatively quick dilution over time and space by mixing and addition of inflow would minimize the concentrations of herbicide that may be delivered to a common point downstream.

### Sediment and Turbidity

As described previously, no measurable increases in sediment or turbidity would occur as a result of the invasive plant treatments proposed the alternatives. The maximum amount of sediment that might be produced from 50 acres of manual treatment within 100 feet of streams in a 6th field watershed is small and does not amount to a detectable amount that would impair water quality.

The Idaho Creek-Summit Creek HUC6 has the largest concentration, of mapped invasive plants at that watershed level within 100 feet of a mapped stream; if all of these were manually treated the amount of sediment that would reach the streams within the watershed amounts to about 0.5 tons total. This same watershed includes about 10.9 miles of forest roads within 100 feet of a mapped stream (approximately 18.5 acres of running surface) would be estimated to produce about 37 tons of sediment per year. The addition of 0.05 tons from maximum manual treatment would not be detectable given the ongoing sediment that is contributed from the roads. The road surfaces are contributing sediment every year, though rates will vary widely according to slope and drainage.

Livestock grazing near streams may also result in sediment delivery. Surface erosion can result from trampling and trailing but the primary affect is to channel condition. Channel condition can be affected by hoof action (i.e., trampling, hoof shear, post holing) and the reduction and vigor of palatable woody streamside vegetation. It is not possible to quantify livestock generated sediment because of the dispersed character of the impacts, problems with distinguishing between cattle and wildlife impacts, inability to attribute or portion channel affects specifically to livestock, and inability to separate long term (decades) affects from past management or events from current management. Allotment management is expected to result in increased riparian protection and less sediment production from grazing.

### Water Temperature

Overall, no measurable increases in water temperature are expected to occur as a result of the invasive plant treatments proposed. While the high water temperature may be attributed to loss of shade from past activities such as roading, logging and grazing, this project does not have the potential to result in a loss of shade. The type of plants that would be removed from streamside areas and the treatment caps would minimize potential for water temperature increases. All foreseeable future projects would be planned to retain shade and would not combine with this project to increase water temperature.

### Water Chemistry

No measurable increases in pH or chlorophyll a or decrease in Dissolved Oxygen (DO) are expected to occur as a result of the invasive plant treatments proposed. There would not be any cumulative effect to pH, DO, or chlorophyll.

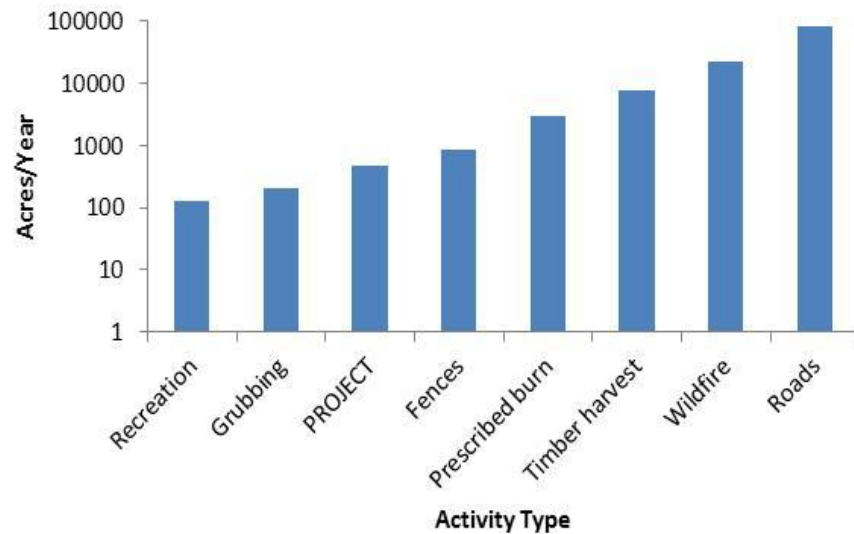
### Herbicides in Water

Most of the National Forest System lands being analyzed for this FSEIS are in headwater areas (upstream of other sources of herbicides). Some agricultural use, and therefore probably herbicide use, may occur upstream of National Forest System lands. The potential for accumulation downstream would be based on the potential for herbicide from agricultural use to reach the water in a measurable amount to where the Forest Service proposes treatment and then for there to be a

measurable amount from Forest Service treatments, so the two sources could combine. Several conditions make this highly unlikely. First, herbicide use on agricultural lands would have to reach the stream in sufficient quantity to not be diluted downstream. Research by Evans and Duseja (1973) however, found picloram concentrations diluted 85 to 98 percent 100 meters (328 feet) below treatments areas and below detection levels at 1000 meters (3281 feet) following a 1.5 inch rainstorm within the first week of spraying. Application rates were 1 and 2 lb/ac (3 to 6 times typical application rate) on test plots ranging from 1 to 2 acres.

Second, this project's protective measures make it very unlikely that herbicide would reach streams in measurable concentrations. Protective measures include PDFs that limit application rates, limit application method near water, restrictions on the type of herbicide that can be used near water, intensity of treatments, and limited scale of infestations. Any herbicide reaching the stream would be quickly diluted as it moved downstream. In the case of aquatic glyphosate, the herbicide most prescribed for streamside treatments, would become biologically inactive upon contact with organic matter in the stream or stream bank. Even though there are relatively large amounts of invasive plant treatment proposed in these two watersheds, the treatment caps limit the amount of area treated with herbicide within 100 feet of streams annually to 10 acres per 6th field waters. The amount of herbicide potentially reaching a common downstream point and combining with chemicals from agricultural uses is very low and would not result in cumulative effects. Mixing and dilution of any trace amount of herbicide that may result from invasive plant treatment would occur quickly, making it highly unlikely that herbicide concentrations would be additive or synergistic with similar treatments at the watershed scale.

Accumulation of residue from repeated treatments has been addressed in the PDFs. Given the half life of the herbicides being used, PDFs restricting those with longer half lives to only one application in a calendar year, buffers and application methods limiting the risk of herbicides reaching water, and the time between treatments, measurable concentrations would be very unlikely. The scattered nature of treatments, and dilution over time and space by mixing and addition of inflow downstream, the amount of herbicide that may be delivered to a common point downstream is very small to non-existent.



**Figure 6 Acreage of activity per year, includes Project manual treatment**

### Compliance with Forest Plan and Other Relevant Laws, Regulations, Policies and Plans

All land management activities on USFS lands are to be conducted in accordance with Forest Plan standards and guidelines and BMPs. Land Management Plans are developed by the USFS for each National Forest, following public review and comment. Use of water quality and other resource protection BMPs in National Forests is required by the National Forest Management Act (NFMA) and prescribed in the Forest Plans. Consequently, all land management activities, must be implemented using BMPs for control of non-point source water pollution (USDA 2011).

The anti-degradation EPA policy 40 C.F. R. Section 131.12 states that existing water quality, even when it exceeds required levels for stated beneficial uses will be maintained. Potential effects of the proposed action, either through surface runoff of sediment and chemicals or chemicals entering water bodies through groundwater sources do not constitute a significant degradation of quality or impair existing beneficial uses.

### Summary of Effects

Weeds are throughout the Forest but concentrated in the Middle Fork John Day drainage. Given application rates proposed for treatment, concentration of herbicides approaching levels of concern for health hazards is unlikely. Half-life period, solubility or adsorption of each herbicide determines how readily each will transport off site. The greatest risk to water contamination is the possibility of transport of residue herbicide on roads that have direct connection to a stream channel. In these circumstances engineered drainage features may effectively circumvent buffers. However, the concentrations of the herbicides are likely to be very much below toxic level for any organism for which research tests are available. Herbicide half-life period largely precludes cumulative effects from multiple treatments at a single site.

The result of the GLEAMS model runs on various scenarios of real sites agrees well with results of several monitoring studies reviewed by Bakke (2001) and Berg (2004). Amounts of herbicides

in natural streams were below levels of concern for aquatic health, and mostly the result of drift from broadcast or aerial application, and aerial application at least is not an option with any of the action alternatives.

The effect of manual treatment of invasive plants is slight to non-measurable, even if all known acreage within 100 meters of streams were treated manually in a single year or if the maximum amount of treatment within 100 feet of a stream was treated every year.

### *Alternative C – Strict Limitations on Herbicide Use*

#### Direct and Indirect Effects

Alternative C would not allow any herbicide use within 100 feet of a stream. The “effective off site application rate” from table 1 was run to approximate the influence of the 100 foot buffer no-herbicide buffer so that the maximum EDRR scenario can be compared between the alternatives. Aminopyralid and glyphosate resulted in no water contamination in the EDRR scenario for alternative B, thus they were not rerun for alternative C. Picloram was not rerun because it is not allowed in alternative C.

**Table 6 Alternative C EDRR run for Ennis Creek**

Chemical	App'l Rate (lbs/acre a.i.)	Conc. At 12" (Mg/l)	Conc. At 36" (Mg/l)	Water Peak Conc. (Mg/l)	Eff. App'l Rate offsite (lbs/acre a.i.)
Chlorsulfuron	0.13	0.0016	0.0000	0.0000	0.0000
Clopyralid	0.5	0.0001	0.0000	0.0000	0.0000
Imazapic	0.19	0.0038	0.0000	0.0001	0.0002
Imazapyr	0.70	0.034	0.0000	0.0004	0.0030
Metsulfuron Methyl	0.0075	0.0007	0.0000	0.0000	0.0000
Sethoxydim	0.47	0.0012	0.0000	0.0001	0.0000
Sulfometuron Methyl	0.38	0.0001	0.0000	0.0000	0.0000
Triclopyr	6.00	0.0065	0.0000	0.0000	0.0001

#### Results

These results indicate that a 100 foot buffer would effectively eliminate chlorsulfuron, clopyralid, metsulfuron methyl, sulfometuron methyl and triclopyr from reaching Ennis Creek. Small amounts (less than 1 part per billion) of imazapic, imazapyr, and sethoxydim could reach the stream, however all results are under a threshold of concern for aquatic organisms and other beneficial uses. The rate restrictions and treatment caps would further reduce the potential for water contamination.

The number of treatment areas acres that are within 100 feet of a stream is 471. These acres would not be treated using herbicides but could be treated using non-herbicide methods. Under alternative C, all of the alternative components for alternative B would be followed, with the following additions and changes:

- No broadcasting of herbicide would be allowed. No boom spraying would be allowed. Maximum herbicide application rates per acre would be reduced by about 30 percent across the board. PDFs related to broadcast spraying would become non-applicable.

- No herbicide use would be allowed within the boundaries of any mapped infestation area that at any point is within 100 feet of creeks, lakes, ponds and wetlands. Non-herbicide methods would continue to be used within these areas the buffer tables would become non-applicable since no herbicide use would be allowed within 100 feet of streams.
- Picloram would be eliminated from the list of available herbicides, due to its persistence, mobility and toxicity.

These restrictions would apply to known sites as they change over time, as well as new detections. The implementation planning process would be similar to alternative B, however the range of treatments that would be allowed would be more restrictive. With the further restrictions of this alternative and given results of Alternative B GLEAMS model runs it has been demonstrated that no detectable measures of chemicals would occur in stream water with either alternative. Site #1 is the only modeled run that had no particular buffer on the stream for Alternative B and in Alternative C would have the minimum of 100 feet.

### Cumulative Effects

As with Alternative B there are no other activities that use herbicides on the forest, and water concentrations of chemicals under Alternative C would be below measured levels of concern. While the likelihood of sediment production may be slightly greater in Alternative C due to the no herbicide buffer, the amount of sediment that could be delivered to streams would be below detectable levels, thus even if it combined with sediment produced from the roads and from other projects, there would not be a discernable cumulative effect.

### Summary of Effects

There would be slight decreases in water concentration of chemicals due to use of wider stream buffers, but as with Alternative B these levels are barely at detectable levels and far below levels of concern for aquatic organisms. There is the potential for increase in sediment delivered to streams because of manual treatment within the buffers however this level of activity is well below current delivery rates and likely not at measurable levels in streams which contain known aquatic resources.

## *Alternative D – No Forest Plan Amendment, No Aminopyralid*

### Direct and Indirect Effects

Alternative D would be identical in effect to alternative B, except a Forest Plan amendment would not be completed and aminopyralid would not be approved for use on the Forest. Aminopyralid would not be used to treat known sites or new detections. All of the components of Alternative B would apply, except for those that refer to aminopyralid would not be included. Compared to Alternative B, more picloram, clopyralid, and glyphosate would likely be used in lieu of aminopyralid. Glyphosate, although has a high water solubility also has very strong adsorption qualities and in the GLEAMS model runs never penetrated beyond 8 inches into the soil. It also has a moderately higher toxicity to aquatic organisms than the other chemicals being considered here, though never, in the model runs because of adsorption rate, registered detectable limits of concentration in water. Model runs assume high maximum application rates of 7 pounds per acre. It is not expected that wider use of glyphosate due to selection of this alternative would lead to water concentrations higher than the model results.



Picloram also has very high water solubility and low absorption rate to soil, so the chemical has a high ability to transport with groundwater, and is very stable under anaerobic conditions. Otherwise it has average or even low persistence in research studies. Still, its toxicity to fish and invertebrates is relatively high and because of its transportability and persistence in sediments (where anaerobic conditions might prevail), and general use, it poses one of the greatest environmental risks of the entire suite of chemicals being proposed.

Clopyralid has moderately low solubility and soil absorption rate. Toxicity to aquatic organisms is also low with LC<sub>50</sub> concentrations many orders of magnitude above modeled runs. Clopyralid has however high resistance to degradation, particularly in absence of sunlight, nonetheless it is not expected that increased use of clopyralid will pose greater risk than model results imply.

### Cumulative Effects

As with Alternative B there are no other activities that use herbicides on the forest, and water concentrations of chemicals under Alternative D would be below measured levels of concern. The potential for sediment delivery to channels would also be very similar to Alternative B which is far below current levels associated with roads and ground disturbing activities, and below detectable levels.

### Summary of Effects

There would be no appreciable difference in chemical water concentration under Alternative D over Alternative B. Effects of manual or mechanical treatment in terms of should be nearly identical as well to Alternative B.

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